MACHINE LEARNING ASSISTED SATELLITE BASED POSITIONING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Patent Application Ser. No. 62/716,912, entitled "MACHINE LEARNING ASSISTED SATELLITE BASED POSITIONING," filed Aug. 9, 2018, which is hereby incorporated by reference in its entirety for all purposes.

TECHNICAL FIELD

[0002] The present description relates generally to satellite based positioning, including using machine learning to assist with satellite based positioning to estimate device location.

BACKGROUND

[0003] An electronic device such as a laptop, tablet, smartphone, a wearable device or a navigation system of a vehicle to which a mobile device is attached may include a GNSS receiver, which is configured to receive signals from Global Navigation Satellite System (GNSS) satellites, to estimate the location of the electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Certain features of the subject technology are set forth in the appended claims. However, for purpose of explanation, several embodiments of the subject technology are set forth in the following figures.

[0005] FIG. **1** illustrates an example environment in which an electronic device may use a machine learning model in conjunction with GNSS positioning to estimate device location in accordance with one or more implementations.

[0006] FIG. **2** illustrates an example network environment for providing a machine learning model to an electronic device for use with GNSS positioning in accordance with one or more implementations.

[0007] FIG. **3** illustrates an example electronic device that may implement the subject system for using a machine learning model in conjunction with GNSS positioning in accordance with one or more implementations.

[0008] FIGS. **4**A-**4**B illustrate example processes for obtaining input data, and generating a machine learning model based on the input data in accordance with one or more implementations.

[0009] FIG. **5** illustrates an example of a location estimator of the subject system that may be implemented by an electronic device in accordance with one or more implementations.

[0010] FIG. **6** illustrates a flow diagram of an example process for generating a machine learning model in accordance with one or more implementations.

[0011] FIG. **7** illustrates a flow diagram of an example process for using a machine learning model in conjunction with GNSS positioning in accordance with one or more implementations.

[0012] FIG. **8** illustrates an example electronic system with which aspects of the subject technology may be implemented in accordance with one or more implementations.

DETAILED DESCRIPTION

[0013] The detailed description set forth below is intended as a description of various configurations of the subject technology and is not intended to represent the only configurations in which the subject technology can be practiced. The appended drawings are incorporated herein and constitute a part of the detailed description. The detailed description includes specific details for the purpose of providing a thorough understanding of the subject technology. However, the subject technology is not limited to the specific details set forth herein and can be practiced using one or more other implementations. In one or more implementations, structures and components are shown in block diagram form in order to avoid obscuring the concepts of the subject technology.

[0014] A location estimation system implemented by an electronic device may include a GNSS receiver, which is configured to receive signals from Global Navigation Satellite System (GNSS) satellites, to estimate the location of the electronic device. However, computing an accurate position solution (e.g., an estimated device location) can be difficult in certain environments. Challenging signal environments (e.g., urban canyons, areas of dense foliage, areas near or within structures such as buildings, and/or other areas that may interfere with line of sight reception of signals) can complicate the computation of an accurate position solution. Another example of a challenging signal environment is outright blockage of the line of sight signal, making the tracked signal solely that of a reflection (e.g., this may only be single path from a GNSS transmitter to a receiver, but may still be misinterpreted by a receiver that uses a simple line of sight model for measurements). In the above-mentioned environments, fewer signals are available (e.g., due to the interference caused by the environments), and those signals that are available tend to yield less accurate measurements on a device due to environmental attenuation. One example of interference for GNSS signals is multipath error, for example, where signals are reflected, refracted and/or absorbed, resulting in multiple paths of arrival for the electronic device.

[0015] The subject system implements a machine learning model (e.g., or machine learning method(s)) to assist with GNSS positioning, e.g. in order to compensate for the incomplete and/or distorted GNSS signal information in these challenging signal environments. The subject system generates a machine learning model, for example, by comparing GNSS position estimates (e.g., or estimated measurement errors) as provided by a GNSS positioning system with corresponding reference position estimates as provided by a reference positioning system (e.g., where the reference positions correspond to ground truth data). In one or more implementations, the ground truth data may be better (e.g., significantly better) than what a mobile device alone can perform in most non-aided mode(s) of operation. For example, a mobile phone in a car may be significantly better aided than a pedestrian device, because the motion model for a vehicle is more constrained, and has aiding data in the form of maps and sensor inputs.

[0016] The machine learning model is trained based on comparisons between the GNSS position estimates and reference positioning system estimates at respective times, together with parameter(s) indicating a position of the